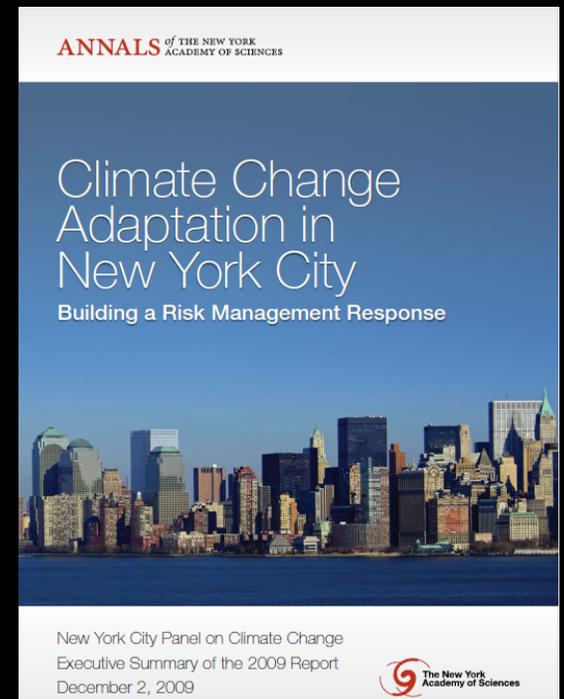




New York City's Adaptation Process



Photo: S. Cornwell

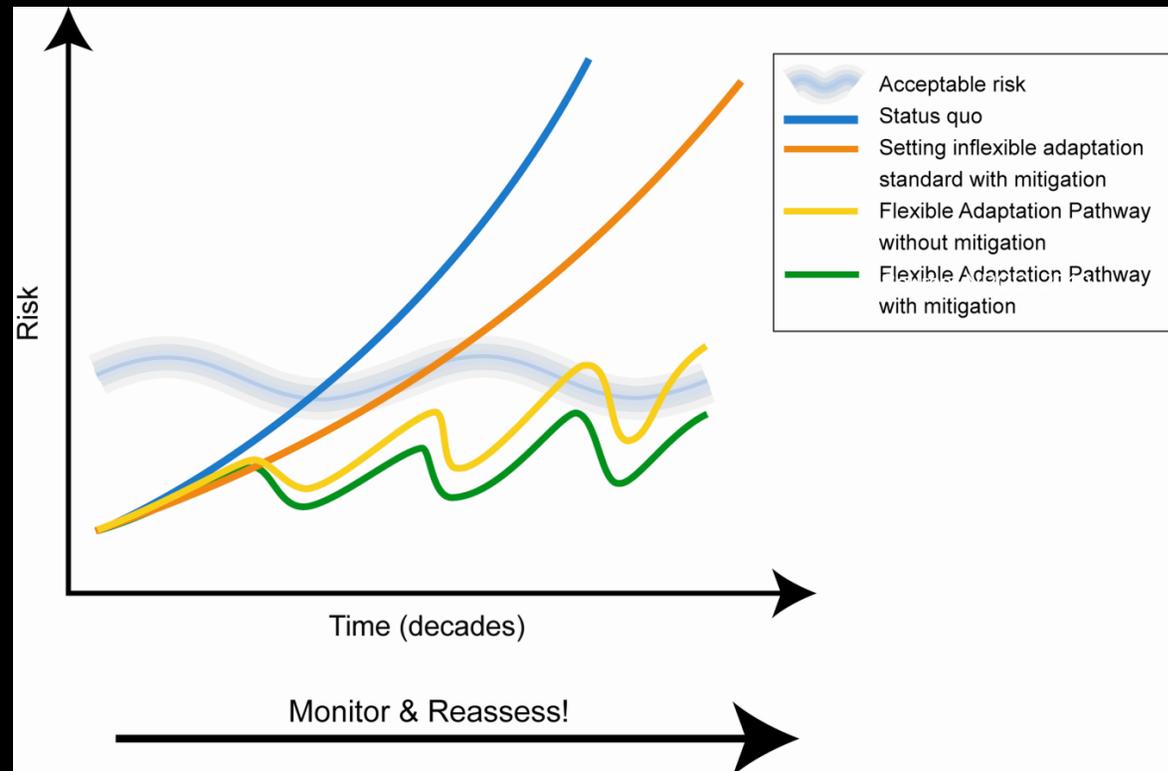


Cynthia Rosenzweig
NASA Goddard Institute for Space Studies
NASA Ames Climate Change Adaptation Symposium
Mountain View, CA, February 4, 2011



Establish Guiding Principles

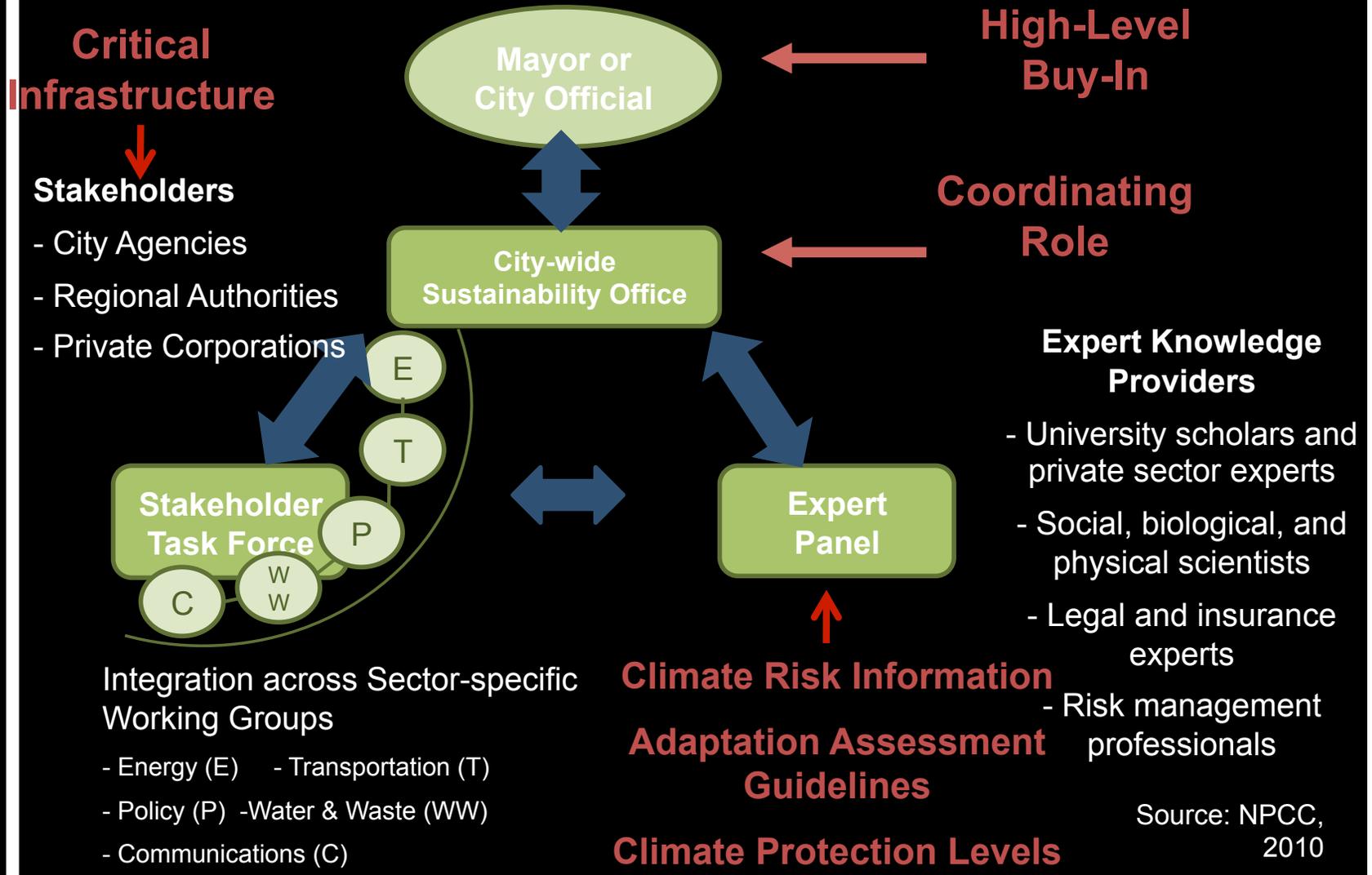
Flexible Adaptation Pathways



Key elements to achieve Flexible Adaptation Pathways are a guiding framework, stakeholder engagement, expert knowledge providers, recurring assessment process, Action Plans by decision-makers, and vertically/horizontally integrated projects with ongoing evaluation



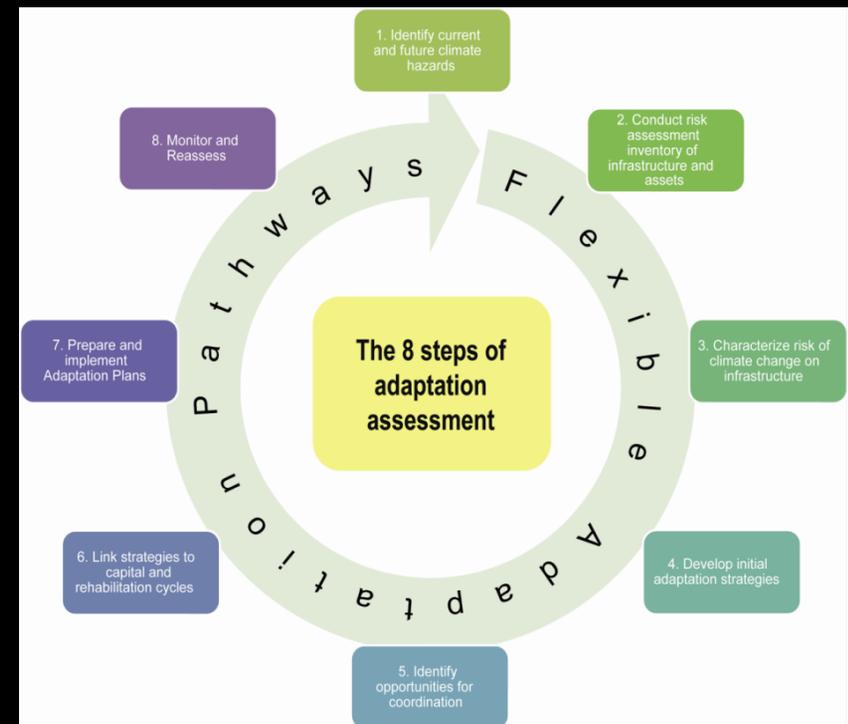
New York City Climate Change Adaptation Process





Design Adaptation Process

1. Identify current and future climate hazards
2. Conduct inventory of infrastructure and assets and begin to identify vulnerabilities
3. Characterize risk
4. Develop initial list of strategies
5. Identify opportunities for coordination
6. Link strategies to capital and rehabilitation cycles
7. Prepare and implement Adaptation Plans
8. Monitor and reassess





Developing Climate Risk Information

Process used to develop climate risk factors for New York City

Global climate scenarios

- SRES greenhouse gas emissions pathway
- GCM simulations



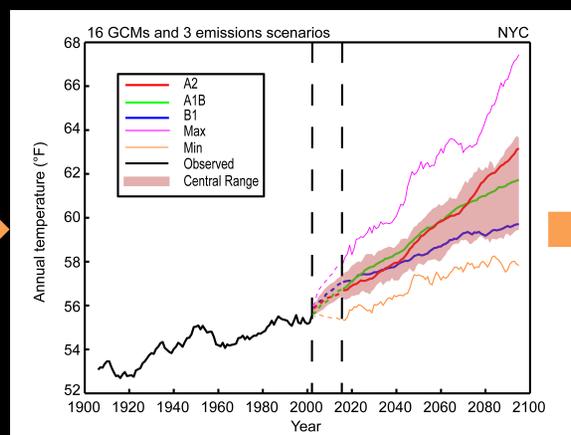
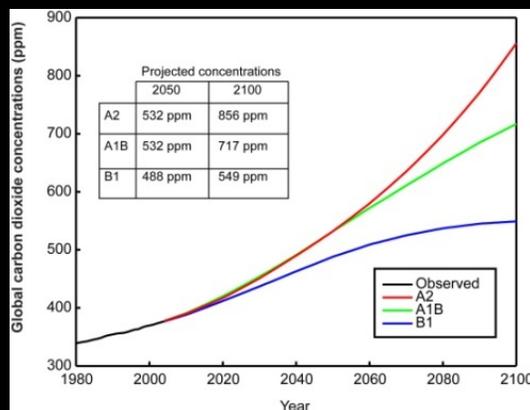
Local climate change information

- Observed data
- Quantitative GCM-based projections
- Qualitative GCM-based projections



Climate risk factors

- Generalized climate hazards of most consequence to NYC infrastructure used to determine critical infrastructure at-risk.



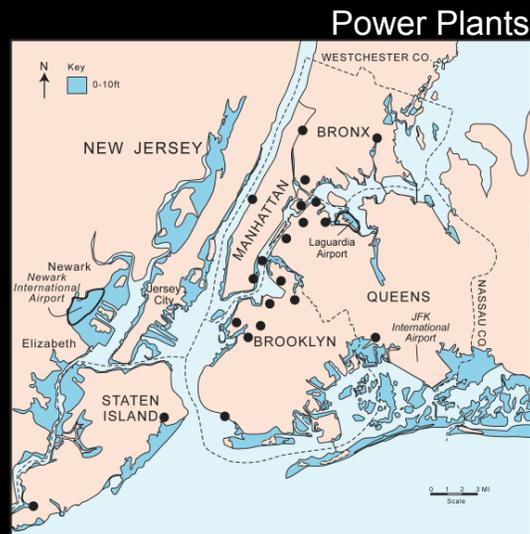
- Warmer temperatures
- More frequent and intense heat waves
- Sea level rise and coastal flooding



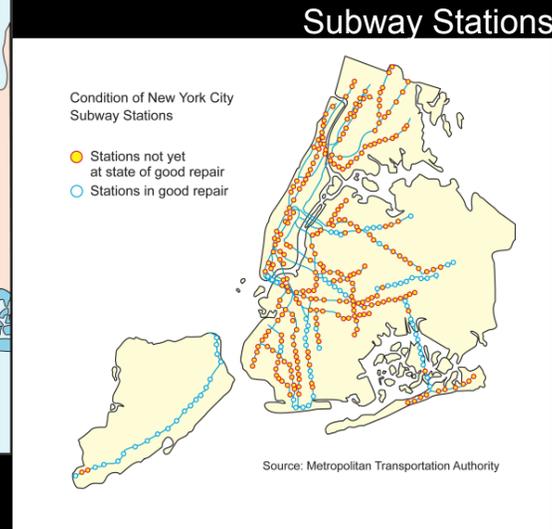
Identify Infrastructure Vulnerabilities

Sea Level Rise

- Equipment damage from salt-water corrosion
- Flooded utility corridors impeding service

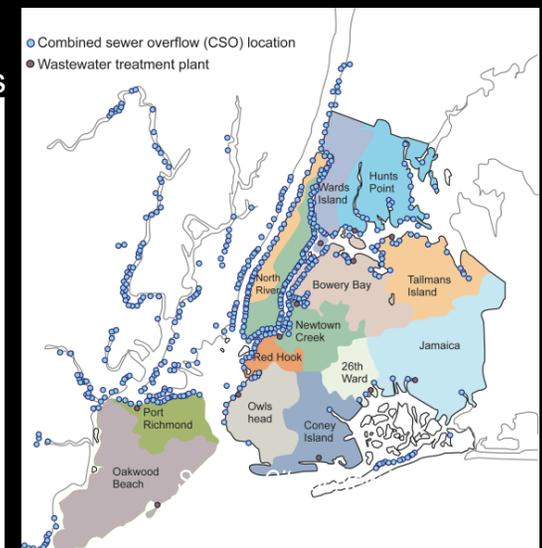


Source: Columbia University Center for Climate Systems Research



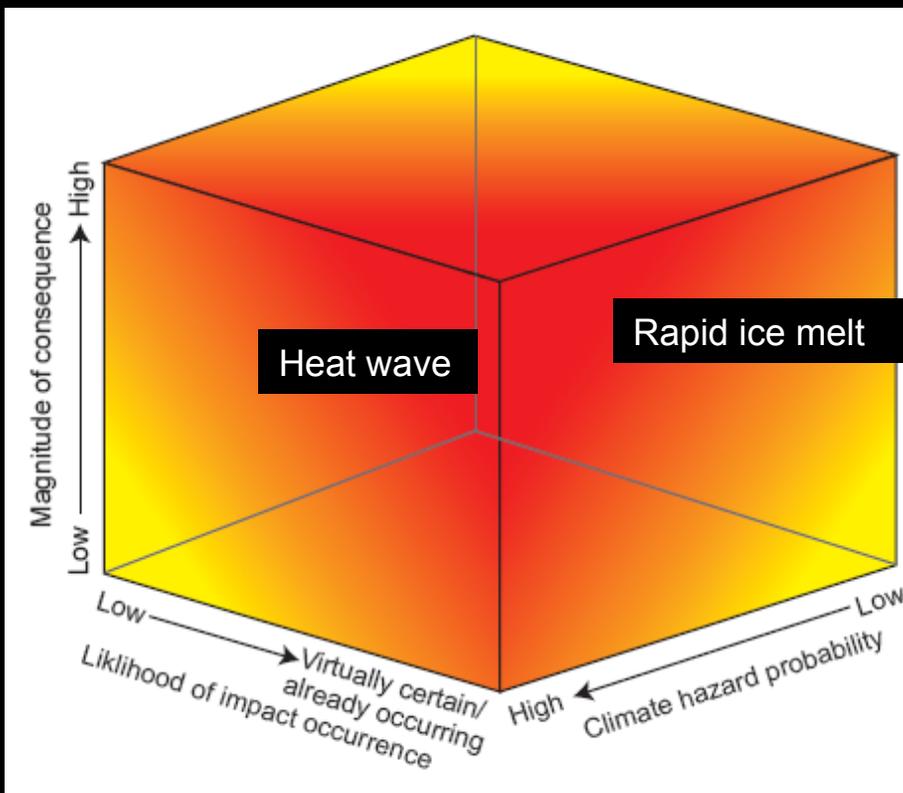
Source: City of New York PlaNYC

Wastewater Treatment Plants & CSO Events





Characterize Risk



To determine risk of climate change on infrastructure

1. Probability of a climate change hazard
2. Likelihood of that hazard causing an impact
3. Magnitude of consequence, should that impact occur

Red	risks for which adaptation strategies should be developed
Orange	risks for which adaptation strategies may need to be developed or for which further information is needed
Yellow	risks for which impacts should be monitored but which may not need actions at this time

Source: Columbia University Center for Climate Systems Research



Develop and Prioritize Adaptation Strategies

Potential Strategy Prioritization Categories

- Cost
- Feasibility
- Timing of Implementation
- Efficacy
- Resiliency Rating
- Co-benefits

Adaptation Strategy	Strategy Cost (1 = low to 3 = high)	Strategy Feasibility (1 = high to 3 = low)	Timing of implementation (1 = high to 3 = low)	Efficacy (1 = high to 3 = low)	Resiliency rating (1 = high to 3 = low)	Co-benefits (1 = high to 3 = low)	Average*	Notes & institutional considerations
Clean drains	1	1	1	2	2	2	1.8	
Build flood walls	3	2	2	1	3	2	2.2	

*1 = high priority strategy, 2 = medium priority strategy, 3 = low priority strategy



Framing Adaptation

- *Reduce the level of physical, social, or economic impact of climate change and variability*
- *Take advantage of new opportunities emerging from climate change*



Type

- Management/operations
- Infrastructure – physical components of each sector
- Policy

Administrative Group

- Private vs. public organizations
- Local/municipal, county, state, national

Level of Effort

- Incremental action
- Large-scale shifts

Timing

- Short term <5 yrs; medium term 5-15 yrs; long term >15 years
- Abrupt Changes - tipping points/ policy triggers

Scale

- Wide-spread, clustered, isolated/unique



Adaptation Decisions

- **Actions**
 - Enhance existing programs
 - Move pumps at the Rockaway Wastewater Treatment Plant to 14 feet above sea level
- **Planning**
 - NYC DEP Climate Change Integrated Modeling Project (CCIMP) analyzing climate impacts on NYC water supply
 - NYC DEP RFP to study impacts of rising sea level on Wastewater Pollution Control Plants (WPCP), tide gates, & other structures
- **Standards and Regulations**
 - NPCC Recommendation to change 1/100 year floodplain standards
- **Urban Design - MOMA**



Ashokan Reservoir



WPCP in Bronx, New York

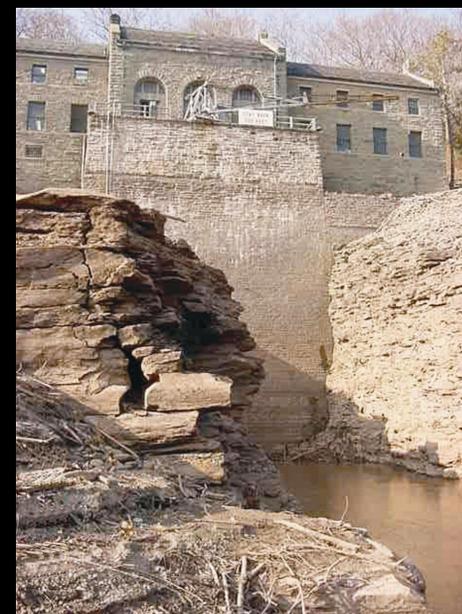




Water Availability and Quality Adaptation Strategies

Water Availability

- Diversify water sources (desalination, expand groundwater system)
- Expand water conservation and usage restrictions
- Expand water transfer capabilities



Water Quality

- Acquire additional land and expand conservation programs
- Increase operational flexibility
- Treat with chemicals as necessary





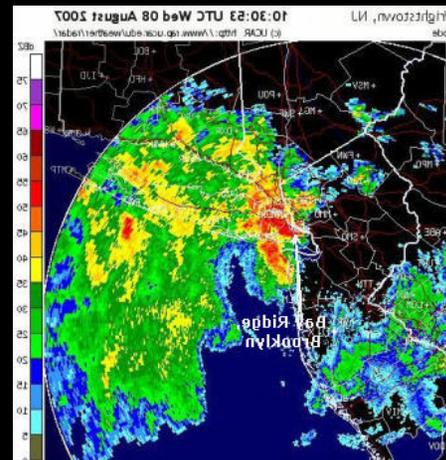
Drainage and Wastewater Management Adaptation Strategies

Rainwater Drainage

- Improve collection (expand sewers and pumps, and retain stormwater above ground)
- Enhance natural landscape and drainage
- Plan for controlled flooding

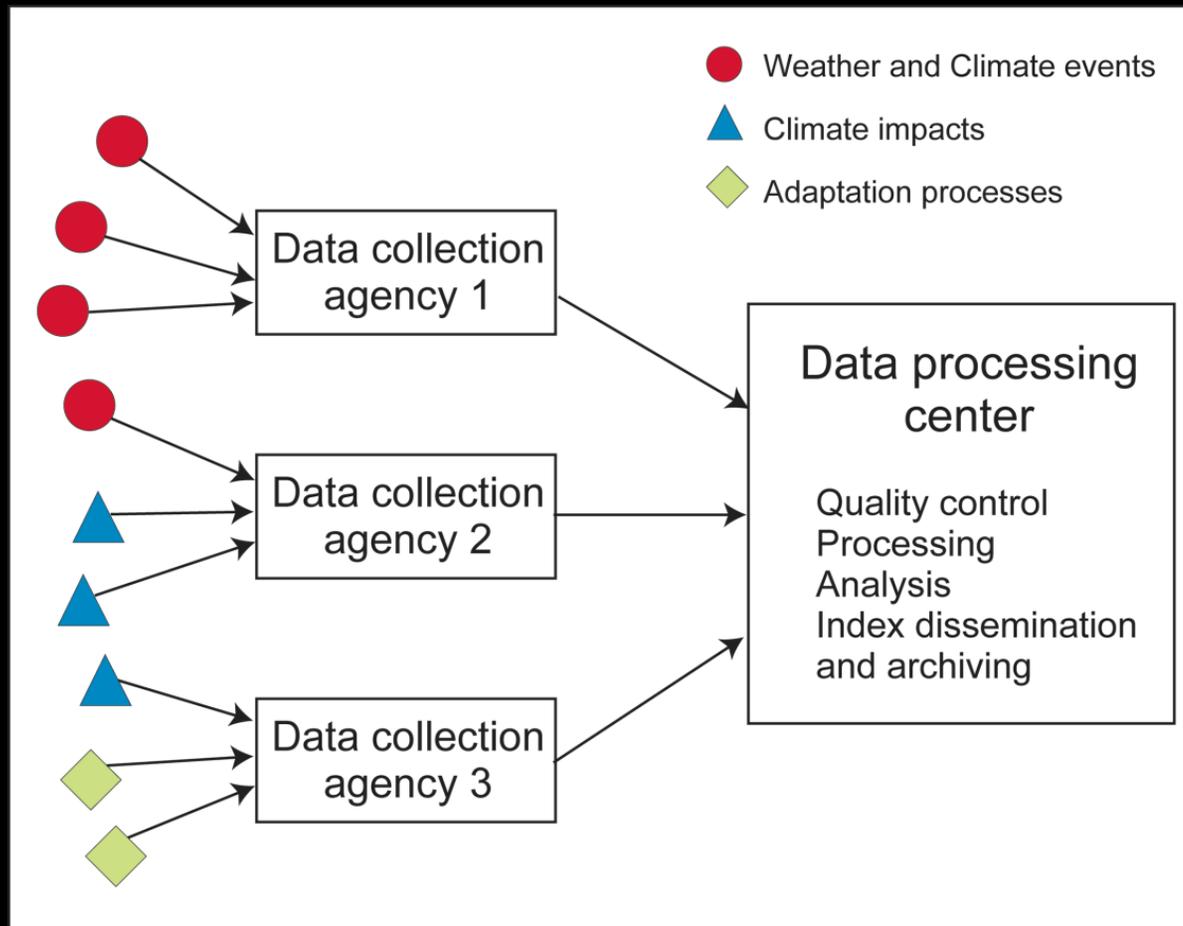
Storm Surge & Treatment

- Raise elevation of key infrastructure
- Use watertight containment of key equipment
- Have reserves of key equipment
- Install local protective barriers
- Allow some inundation in defined areas





Monitor and Reassess



Proposed structure and process of monitoring climate change, impact, and adaptation parameters, and for translating them into indicators for New York City



Recommendations for Action

- Involve multiple partners, including scientific experts, in the process, with high-level proactive leadership and bottom-up involvement
- Create a standard set of regional climate scenarios
- Adapt a risk-based approach to develop Flexible Adaptation Pathways
- Focus on strategies for incremental changes as well as for long-term low-probability, high-impacts events
- Pay particular attention to early win-win strategies
- Work with the legal, engineering & insurance industries
- Conduct a review of standards and codes
- Create a mandate for an on-going body of experts
- Establish a climate change monitoring program



Further Study

- Identify, characterize, and understand nonlinear tipping points, triggers, and decision pathways
- Analyze the economics and financing of adaptation
- Conduct feasibility study of non-structural and structural citywide protective measures
- Do sensitivity tests of critical infrastructure facilities and operations
- Study the interdependencies between and within infrastructure sectors and systems



Climate Adaptation Science Investigators (CASI) Objective

Advance and apply NASA's scientific expertise and products to develop climate adaptation strategies that support NASA's overall mission by minimizing risks to each center's operations, physical assets, and personnel

